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(54) Title of the Invention: **A Soundproof Carpet**

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**SPECIFICATION****1. Title of the Invention**

A Soundproof Carpet

**2. Claims**

1. A soundproof carpet backed with polyurethane foam, comprising a carpet foundation cloth, an intermediate layer, and a polyurethane foam layer, said carpet characterized by being formed from ethylene-unsaturated carboxylic acid copolymer or a metal salt thereof, and using

an intermediate layer whereon surface treatment has been performed by introducing a polar group to the polyurethane foam bonding surface.

2. The soundproof carpet cited in claim 1, having a low density polyethylene layer disposed between the carpet foundation cloth and the intermediate layer.

### **3. Detailed Description of the Invention**

#### **(Field of Industrial Utilization)**

The present invention relates to a soundproof carpet, more particularly, to a soundproof carpet used for automobile carpets, tile carpets, and the like.

#### **(Prior Art)**

Automobile carpets are widely used as interior materials that provide decoration to the vehicle interior, a protective means against dust, soundproofing, and other benefits, and carpet backed with an ethylene vinyl acetate copolymer or other compound blended with low density polyethylene or with calcium carbonate or another inorganic filler is press-worked so as to fit the irregular floor surface of an automobile.

Among such carpets for automobiles are carpets thinly backed with low density ethylene that are light and inexpensive, but have inferior soundproofing performance. Furthermore, carpet backed with ethylene vinyl acetate copolymer blended with a high density inorganic filler, the so-called mass back carpet, has good soundproofing performance, but has the drawback of being heavy.

In view of the above, carpet backed with a polyurethane foam layer has come to be used as a carpet for automobiles that is light and has excellent soundproofing performance.

Such carpet backed with polyurethane foam has an intermediate layer disposed between the carpet foundation cloth and the polyurethane foam layer, and this intermediate layer requires many characteristics including being capable of preventing yarn from being pulled out of the carpet pile, having good bonding properties with polyurethane foam layer formed with injected foam, and having flexibility and a melting point that easily allows heat press working so as to fit into the irregular surface of the floor during installation in an automobile.

However, there is currently no intermediate layer material which has such characteristics as a single component, and there is only a method whereby low density polyethylene/acid

modified polyethylene/nylon laminate film is prepared in advance and laminated so as to obtain bonding in both directions of the low density polyethylene and the polyurethane foam when low density polyethylene is heat-laminated in a hot state to the carpet foundation cloth in order to prevent yarn from being pulled out of the carpet pile.

Such carpet for automobiles also has an overall complex structure of six layers, and because manufacturing is complex, it has a drawback of being very costly in comparison with conventional carpets for automobiles, despite being light and having excellent soundproofing performance.

#### **(Problems Which the Invention Is Intended to Solve)**

An object of the present invention is to provide a soundproof carpet that satisfies the several characteristics required in an intermediate layer described above, reduces the costs and simplifies the structure of a laminated carpet backed with polyurethane foam, and can be used as a carpet for automobiles and other applications.

#### **(Means Used to Solve the Above-Mentioned Problems)**

The object of the present invention is achieved by a carpet backed with polyurethane foam comprising a carpet foundation cloth, an intermediate layer, and a polyurethane foam layer, characterized by being formed from ethylene-unsaturated carboxylic acid copolymer or a metal salt thereof, and using an intermediate layer whereon surface treatment has been performed by introducing a polar group to the polyurethane foam bonding surface.

The carpet foundation cloth is not particularly limited, and tufted carpet, needle punch carpet, or other carpet may be used. Polyester, polyamide, polyacrylonitrile, polypropylene, or the like may further be used as the material thereof. SBR latex treatment, or other precoating treatment may be performed on the reverse side of these original fabrics.

The present invention has a particular intermediate layer as a bonding layer for such a carpet foundation cloth and a polyurethane foam layer, but this type of bonding layer may be directly laminated to the carpet foundation cloth, or it may be laminated by way of low density polyethylene or another substance to improve bonding characteristics, to lower costs, or to achieve other purposes.

Acrylic acid, methacrylic acid, maleic anhydride, monomethyl maleate, or the like may be used as the ethylene-unsaturated carboxylic acid copolymer for forming an intermediate layer, but acrylic acid and methacrylic acid are preferably used. Other unsaturated compounds, such as vinyl acetate and other vinyl esters; methyl, ethyl, *n*-butyl, isobutyl, and other esters of acrylic acid; and methyl methacrylate and other unsaturated carboxylic acid esters may also be copolymerized in this copolymer.

The ratios of the copolymerization components in these copolymers are commonly 40 to 98 wt%, but preferably 50 to 95 wt%, for ethylene; 2 to 40 wt%, but preferably 5 to 30 wt%, for unsaturated carboxylic acids; and 0 to 50 wt%, but preferably 0 to 40 wt%, for other unsaturated compounds.

These copolymers may also use sodium, potassium, magnesium, calcium, zinc, aluminum, or other metal salts, and the degree of neutralizing thereof is 100% or less, but preferably 80% or less.

Compounds having a melt flow rate of (MFR; 190°C, 2160 g load) about 0.1 to 200 dg/minute, but preferably about 0.5 to 100 dg/minute, are commonly used as such copolymers or metal salts thereof.

Surface treatment that introduces a polar group to the polyurethane bonding surface side is performed on the intermediate layer formed from such copolymers (metal salts). The surface treatment is carried out in accordance with treatment methods performed on common plastic films or sheets, examples of which include corona discharge treatment, plasma treatment, flame treatment, ozone treatment, or any other treatment, but corona discharge treatment is preferably used because of the low cost of equipment and ease of operation.

With corona discharge treatment, the surface side bonded with polyurethane foam layer is surface treated by simply passing the copolymer (metal salt) layer side that is laminated with the carpet foundation cloth, or with the extruded film or sheet of copolymer (metal salt) through a corona discharge treatment device. The treated surface is slightly oxidized by this surface treatment, and a hydroxyl group, a carboxyl group, or other polar group is introduced at this time. The quantity of polar group that is introduced is determined according to the intensity of the corona discharge, in other words, the voltage, the distance to the electrode, the treatment time, and other factors.

After firm bonding with the polyurethane foam layer is assured, the surface treatment must be performed so that the wetting tension (JIS K-6768) on the treated surface of the copolymer (metal salt) is about 37 dyne/cm or more, but preferably about 40 dyne/cm.

Polar groups having a hydroxyl group, carboxyl group, amino group, or other active hydrogen species, which is introduced to the surface of the copolymer (metal salt) that constitutes the intermediate layer, react with the polyurethane-forming isocyanate component in the step for injecting and foaming polyurethane foam with the aid of these surface treatment methods. As a result, a firm bond is created between the polyurethane foam and the carpet foundation cloth laminated with the ethylene-unsaturated carboxylic acid copolymer (metal salt).

The bond between the carpet foundation cloth and the intermediate layer can be formed by the following methods, for example.

The first method is a method whereby this copolymer (metal salt), in lieu of the tri-layered polyethylene/acid modified polyethylene/nylon film used as the current intermediate layer of the carpet backed with polyurethane foam, is molded on the film in advance by inflation molding, a T-die cast method, or other method; one side of this film is surface treated; the reverse surface side is thereafter laminated with the low density polyurethane T-die sheet; and the carpet foundation cloth and the polyurethane foam are laminated in the subsequent step by laminating the polyurethane foam layer with the copolymer (metal salt) film layer.

The second method is a method easily achieved with a very simple process whereby the copolymer (metal salt) is directly heat-laminated to the carpet foundation cloth and is subsequently surface treated; in other words, the copolymer (metal salt) is heat-laminated to the reverse side of the carpet foundation cloth using a T-die extruder, the surface is subsequently treated, and the product is then laminated with the polyurethane foam layer in the subsequent step by way of this surface-treated laminated layer.

In either of these methods, the lamination of the polyurethane foam layer is performed in the last step by common foam injection, and carpet backed with polyurethane foam is formed thereon.

#### **(Merits of the Invention)**

The soundproof carpet of the present invention, in which a carpet foundation cloth and a polyurethane foam layer are laminated, and in which an ethylene-unsaturated carboxylic acid

copolymer or a metal salt thereof serves as an intermediate layer, is configured such that yarn pullout from the carpet pile is effectively prevented, adequate adhesion is maintained with respect to the foam-injected polyurethane foam layer, and the current characteristics of carpet backed with polyurethane foam, which include lightness and excellent soundproofing performance, are maintained with a simple structure.

This intermediate layer further acts to prevent the polyurethane from penetrating into the carpet foundation cloth when the polyurethane foam is injected and foamed.

### **(Practical Examples)**

The present invention is subsequently described with practical examples.

#### **Practical Example 1**

While low density polyethylene ( $d = 0.923 \text{ g/cm}^3$ ,  $\text{MFR} = 3.5 \text{ dg/minute}$ ) was extruded in a sheet form with a thickness of about  $300 \text{ }\mu\text{m}$  at a die temperature of  $220^\circ\text{C}$  using a 40 mm diameter extruder ( $L/D = 24$ ) provided with a T-die having a width of 400 mm, carpet foundation cloth (nylon pile first foundation cloth jute) was fed from the upper surface side of the extruded T-die sheet, and a corona discharge treatment film (thickness  $100 \text{ }\mu\text{m}$ ) described below was fed from the lower surface side so that the opposite surface and the corona discharge treatment surface were kept in contact and laminated together by a pressure roller before the low density polyethylene sheet was able to cool and solidify.

#### **Corona discharge-treated film:**

A film composed of ethylene-methacrylic acid copolymer (Nucrel 0903HC manufactured by Du Pont-Mitsui Polychemicals; methacrylic acid content 9 wt%,  $\text{MFR} = 3 \text{ dg/minute}$ ) with a thickness of  $100 \text{ }\mu\text{m}$  was fabricated at an extrusion temperature of  $160^\circ\text{C}$  using an inflation molding machine having a 50 mm diameter extruder. This film was passed through the corona discharge treatment device, and one side of the film was treated by corona discharge and provided with a wetting tension of 45 dyne/cm.

The laminated object composed of the carpet foundation cloth obtained by lamination was cut at a 20 cm angle and placed on the bottom portion of the metal mold for molding injected foam, with the foundation cloth on the lower side. The mixture for molding

polyurethane foam described below was added thereon, and the mold was closed. After twenty minutes the object was removed from the mold with the polyurethane foam laminated.

**Mixture for molding polyurethane foam:**

Polypropylene glycol (MW5000)	100 parts by weight
Triethanolamine	3.5
Ethylene glycol	2.5
Silicon emulsion (L-5305 manufactured by Shin-Etsu Chemical)	1.0
Water	0.6
Pentamethyl diethylenetriamine	0.1
Triethylenediamine	0.2

A premixed liquid (100 g) of the blend composition above was added to 53 g of 4,4-diphenylmethane diisocyanate and agitated at a high speed (4,000 rpm) in a laboratory mixer for 10 seconds while the temperature was maintained at  $20\pm 2^{\circ}\text{C}$ , and the liquid mixture was thereafter used within 10 seconds.

The yarn-pull out strength of the carpet pile of the carpet backed with polyurethane foam obtained in such a manner was 1.6 kgf, and when the polyurethane foam layer and the copolymer film layer treated by corona discharge were separated, the polyurethane layer suffered cohesive failure, confirming that the bonding between both layers was good.

**Comparative Example 1**

The ethylene-methacrylic acid copolymer film (wetting tension 33 dyne/cm) of practical example 1 was used without corona discharge treatment.

The yarn-pull out strength of the carpet pile of the carpet backed with polyurethane foam obtained was 1.7 kgf, but when the polyurethane foam layer and the copolymer film layer were separated, interfacial separation occurred, demonstrating inadequate bonding.

**Practical Example 2**

Inflation film (wetting tension 44 dyne/cm) of practical example 1 composed of the ethylene-methacrylic acid copolymer sodium salt (Himilan H1601 manufactured by Du Pont-

Mitsui Polychemicals; MFR = 1.2 dg/minute) treated by corona discharge on one side was used as the corona discharge-treated film.

When the polyurethane foam layer and the copolymer sodium salt layer (treated by corona discharge) of the resulting carpet backed with polyurethane foam were separated, the polyurethane foam layer suffered cohesive failure, confirming that the bonding between both layers was good.

### **Comparative Example 2**

Inflation film of practical example 2 composed of the ethylene-methacrylic acid copolymer sodium salt (wetting tension 33 dyne/cm) was used without corona discharge treatment.

When the polyurethane foam layer and the copolymer sodium salt layer of the resulting carpet backed with polyurethane foam were separated, interfacial separation occurred, demonstrating inadequate bonding.

### **Practical Example 3**

While ethylene-methacrylic acid copolymer (Nucrel 1207 manufactured by Du Pont-Mitsui Polychemicals; methacrylic acid content 12 wt%, MFR = 7 dg/minute) was extruded in a sheet form with a thickness of about 400  $\mu\text{m}$  at a die temperature of 240°C using the same extruder as in practical example 1, carpet foundation cloth (nylon pile first foundation cloth polyester fiber) was fed to one side thereof and laminated together by a pressure roller before this copolymer T-die sheet was able to cool and solidify.

The laminating side of the carpet foundation cloth and the surface of the copolymer sheet surface on the opposite side were treated by corona discharge to form a corona discharge surface having a wetting tension of 43 dyne/cm.

In the laminated object with the carpet foundation cloth obtained in this manner, polyurethane was backed in the same manner as in practical example 1, and the yarn-pull out strength of the carpet pile was 2.1 kgf for the obtained carpet, and when the polyurethane foam layer and the copolymer layer treated by corona discharge of the carpet backed with polyurethane foam were separated, the polyurethane layer suffered cohesive failure, confirming that the bonding between both layers was good.



### **Comparative Example 3**

Corona discharge treatment was not performed on the copolymer sheet surface (wetting tension 34 dyne/cm) of practical example 3.

When the polyurethane foam layer and the obtained copolymer layer of the carpet backed with polyurethane foam were separated, interfacial separation occurred, demonstrating inadequate bonding.

### **Practical Example 4**

The corona discharge-treated film (wetting tension 45 dyne/cm) of practical example 1 composed of a ethylene-methacrylic acid copolymer zinc salt (Himilan 1652 manufactured by Du Pont-Mitsui Polychemicals; MFR = 5 dg/minute) was used as the corona discharge-treated film.

The yarn-pull out strength of the carpet pile of the carpet backed with polyurethane foam obtained in such a manner was 2.4 kgf, and when the polyurethane foam layer and the copolymer zinc salt layer treated by corona discharge were separated, the polyurethane layer suffered cohesive failure, confirming that the bonding between both layers was good.

### **Comparative Example 4**

Corona discharge treatment was not performed on the copolymer zinc salt film (wetting tension 33 dyne/cm) of practical example 4.

When the polyurethane foam layer and the obtained copolymer layer of the carpet backed with polyurethane foam were separated, interfacial separation occurred, demonstrating inadequate bonding.

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